

Energy consumption in the non-fletton clay brickmaking industry



- Energy survey results for the clay brickmaking industry
- Energy benchmarking to facilitate comparisons between individual site and industry-wide performance
- Energy efficiency measures



ENERGY EFFICIENCY

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BEST PRACTICE
PROGRAMME

ABOUT THIS GUIDE

This Guide, by providing you with industry-wide data, will help you decide whether your particular site is making the most effective use of energy. The Guide uses energy consumption information collected during a 1997 survey supplied by 90 production sites which together account for more than 95% of UK clay brick production.

The Guide:

- uses graphs to examine the sources, applications and consumptions of energy used in continuous and intermittent kiln plants producing non-fletton products;
- shows you how to calculate your specific energy consumption (SEC) and benchmark your performance against the average and best in your sector. The SEC is defined as the amount of energy supplied by conventional fuels, including electricity, to produce each tonne of fired product;
- provides advice on simple actions that can save energy and gives examples of energy-saving measures currently being implemented in the industry. Signposting is given to literature which is available free of charge to help you reduce your energy bill.



SUMMARY OF RESULTS

The Survey

Since 1974 CERAM Research has carried out eighteen fuel usage surveys to gather information about product types, raw materials, manufacturing processes and energy usage throughout the UK clay brickmaking industry.

This Guide uses data from 36 companies operating 90 production sites manufacturing approximately 95% of UK clay brick production. The annual defined production from these sites totalled 7.1 million tonnes of which 6 million tonnes (85%) were classified as non-flettons.

The Industry

To put the energy consumptions and costs in the context of the ceramics industry as a whole, Table 1 compares the performance of the two clay brickmaking sectors with those of other ceramic manufacturing sectors.

The total energy consumption for fletton and non-fletton manufacture is calculated as the combined conventional energy consumed per tonne of raw material. This includes the electricity used in the making, drying and firing processes plus an estimated figure for additional site energy usage. The tonnages of raw material were calculated from the reported fired tonnages assuming an 18.5% ignition loss for flettons and an average ignition loss of 7% for non-fletton products. The comparative results for refractories and industrial ceramics, sanitaryware, tableware and tiles were taken from Energy Consumption Guide 61¹.

Table 1 Energy consumption in the UK ceramics industry

Sector	Average energy consumption (GJ/t)	Total annual energy use (PJ)	Cost (£M)
Brickmaking : Fletton	0.7	0.93	2.5
Brickmaking : Non-fletton	2.7	17.30	40.4
Refractories and industrial ceramics	6.7	5.82	16.0
Sanitaryware	23.8	2.99	13.9
Tableware	32.4	5.09	15.4
Tiles	10.7	2.46	6.0
Total		34.59	94.2

¹ Energy Consumption Guide 61, *Energy consumption in the ceramics industry*. January 1996.

ENERGY CONSUMPTION

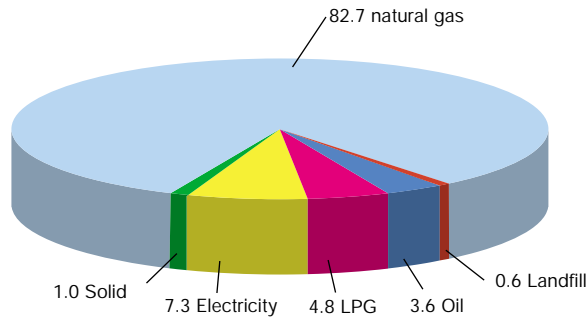


Fig 1 Conventional fuel usage in manufacturing process (%)

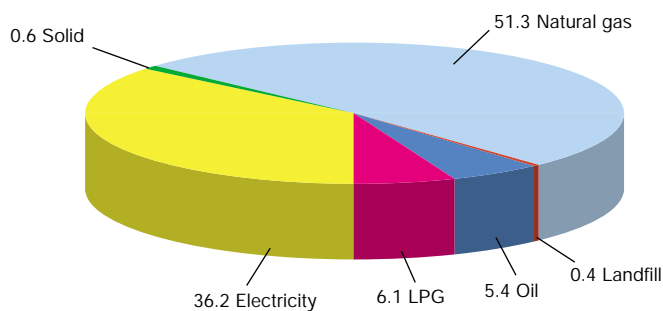


Fig 2 Industry cost of conventional fuels (%)

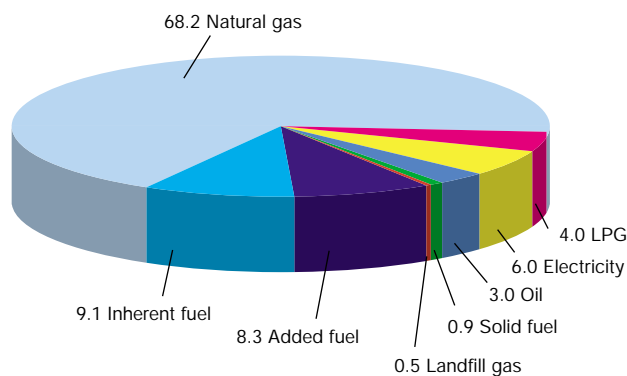


Fig 3 Total energy consumption (%)

The sources and proportions of energy used in non-fletton UK brick production (Table 1) are shown in Figure 1 and the relative costs are given in Figure 2. The energy costs used are the average industry costs applicable in 1998.

Under a combined heading of body fuel, two other potential sources of energy are available to the industry. These comprise:

- Inherent fuel provided by the naturally occurring carbonaceous material present in many UK brick clays. Its potential effect is illustrated by the readily combustible material present in Oxford Clays which accounts for the dramatically lower energy consumption for fletton bricks. In non-fletton production the benefit is often not realised because less readily combustible forms of carbon may require additional conventional fuel to avoid problems such as staining and bloating.
- Added fuel which is provided by the addition of a range of materials containing organic carbon. These can vary in both the carbon content and hence calorific value, covering a range of materials from low grade town ash to high grade commercial coke. Within the non-fletton industry added fuel is used for aesthetic or a combination of aesthetic and energy saving purposes. The amounts added vary considerably dependent on the product.

The theoretical energy contributions made by inherent and added fuel are included in Figure 3. The combined 17.4% energy available from the body fuels equates to 1.9 PJ (18.2Mth) from the carbon inherent in the clays themselves plus 1.7 PJ (16.5Mth) from the carbonaceous additives.

BRICK PRODUCTION PROCESSES

Energy is used in four distinct phases of brick production. Three of these, making, drying and firing, can be closely defined. The fourth covers the remaining site support activities and includes operations such as clay winning and road transport, which are often contracted out.

The results from the 1997 survey indicated that 4.6% of the energy from conventional fuels was used in preparation, 19.8% and 73.4% for drying and firing respectively, and the remaining 2.2% in other site related activities. The relative process energy usages are shown in Figure 4, which also gives the contributions made by the individual fuels.

The energy supplied in product manufacture is largely provided by electrical power. Tentative industry-wide estimates suggest that the grinding, mixing and forming processes account for 60% of the site electricity usage.

The energy required for drying depends on the making method since this determines the moisture content present in the freshly made bricks. In continuous kiln plants much of the energy for drying is supplied by cooling heat transferred from the kiln which may be supplemented by either continuous or intermittent direct heating. The subsequent firing of the dried bricks is the most directly energy intensive of the manufacturing processes, and is carried out using external conventional fuels.

At the other end of the brick manufacturing spectrum, exemplified by the clamp firing of stock bricks, drying and firing tend to be carried out as separate processes. Drying uses external energy while the firing energy is provided by both conventional and, to a much larger extent than in continuous kiln firing, by added body fuel.

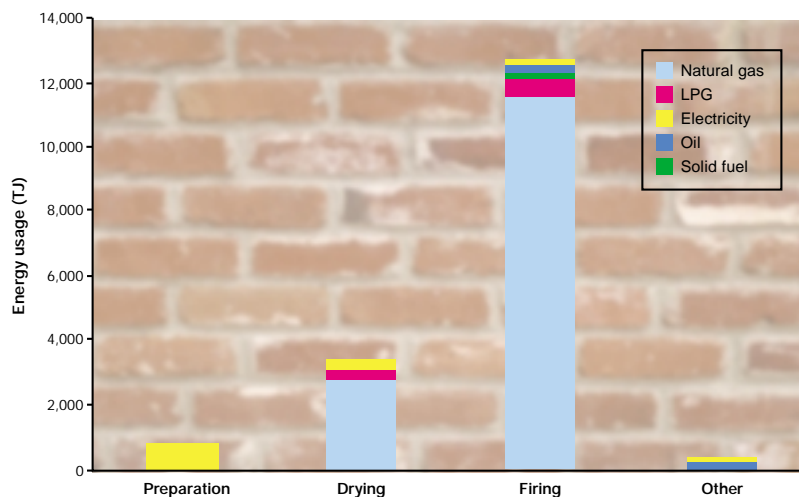


Fig 4 Annual fuel usage (1997)



NON-FLETTON BRICK PRODUCTION

CONTINUOUS KILN SITES

The 1997 survey data indicates that 90% of bricks (by tonnage) were produced in continuous kiln plants. On the majority of sites firing was carried out in tunnel kilns (83) while the remainder was evenly split between the older chamber (8) and Hoffman (7) kilns.

Figure 5 shows the variation in nett SEC, at different sites, for both 1997 and 1984. The comparative figures show a 9.5% energy saving over the fourteen-year period. However, since the electricity component of the SEC increased from 0.18 GJ (1.63 th) to 0.21 GJ (1.97 th) between 1984 and 1997, it is clear that overall energy savings of 11.4% were achieved in conventional fuel usage. To allow a more direct comparison with site data, Figures 6a and 6b show the variation in energy consumption reported for continuous kiln plants in 1997 as SECs calculated with and without electricity.

Figure 7 shows the change in nett specific energy consumption since 1974 when the survey was first conducted. Two sets of data have been plotted to illustrate the variation in SEC for all types of brick fired in continuous kilns and for that proportion comprising extruded facing and engineering bricks. While the values for the extruded facing and engineering brick production show a general decrease, more fluctuation occurs in the histogram relating to total production.

The markedly lower SEC for the total production in 1974 reflects the high level of low grade, low energy

common bricks being produced at that time. The dramatic fall in common brick production of almost 90% that occurred between 1974 and 1980 is the reason for the subsequent convergence of the facing/engineering and total brick production figures. In the mid to late 1980s the steady decrease in SEC was slowed by an increasing demand for soft mud bricks which require more energy for moisture removal. In the early 1990s a recession occurred in the clay brickmaking industry. The resultant drop in brick production, and associated increase in SEC, clearly demonstrate that tunnel kilns are best operated at optimum throughput.

From the information for continuous kiln sites it is possible to extract a sub-group of 27 outwardly comparable sites. The resultant SECs shown in Figures 8a and 8b, indicate that considerable differences continue to exist in this more selective grouping. Even for plant which is outwardly comparable, there is wide variation in SEC between sites, suggesting there may be scope to improve the energy efficiency of the least efficient sites.

An important reason for the difference in performance within the grouping has been the investment in the replacement and refurbishment of older kilns. In addition, the types of clays used, with their individual vitrification characteristics, together with the range of products fired in tunnel kilns, will also exert a significant effect on the SEC.

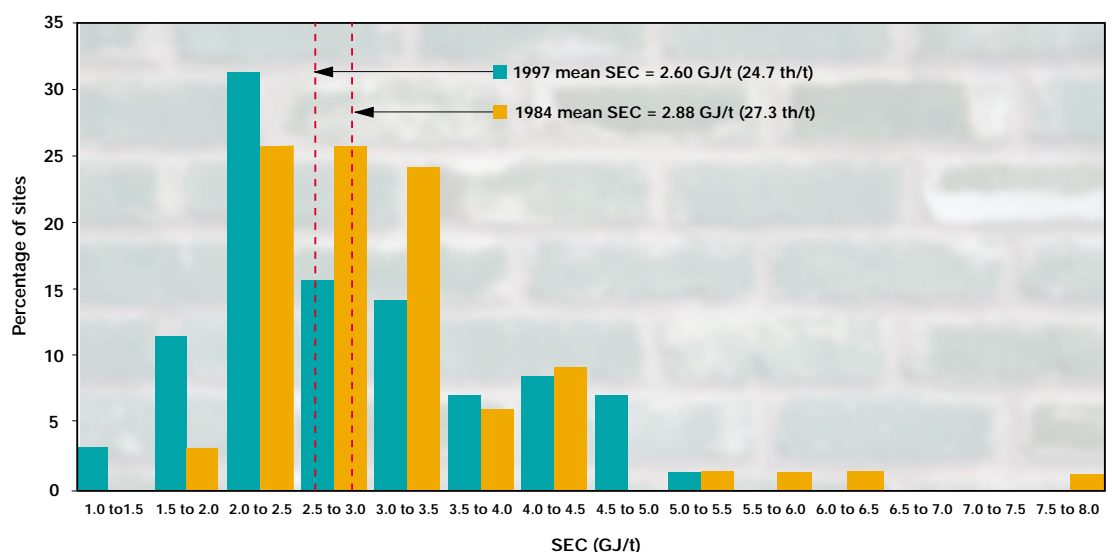


Fig 5 Comparative Specific Energy Consumption for continuous kiln sites.

NON-FLETTON BRICK PRODUCTION

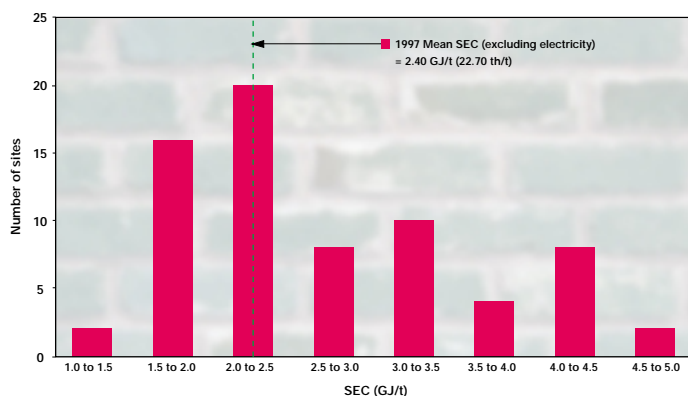


Fig 6a Specific Energy Consumption excluding electricity for continuous kiln sites

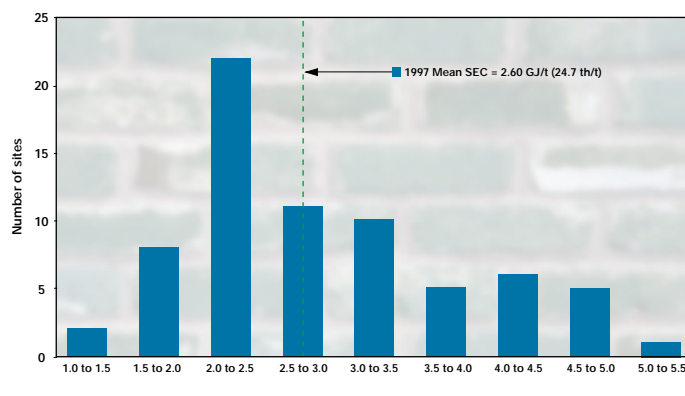


Fig 6b Specific Energy Consumption including electricity for continuous kiln sites

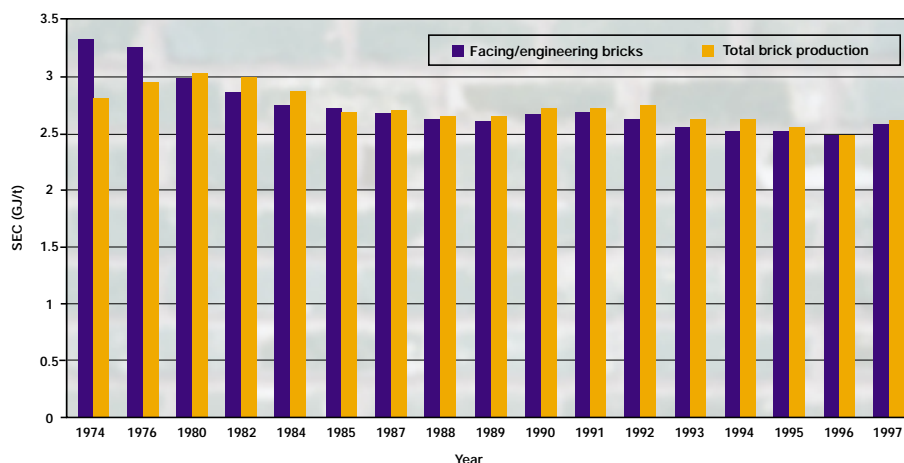


Fig 7 Trend in Energy Consumption for continuous kilns over period 1974 - 1997

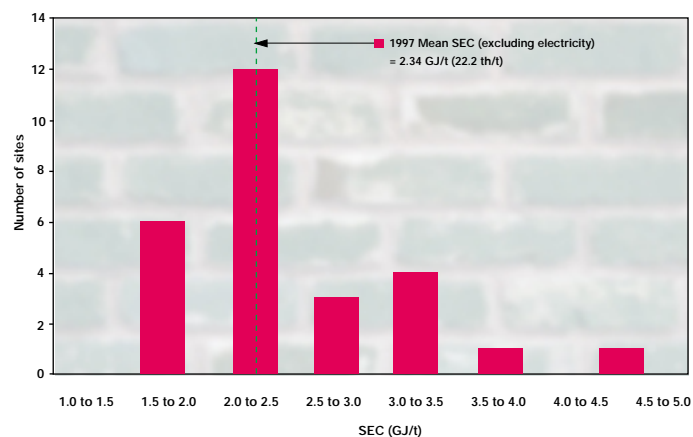


Fig 8a Specific Energy Consumption excluding electricity: tunnel kiln sites producing extruded shale bricks

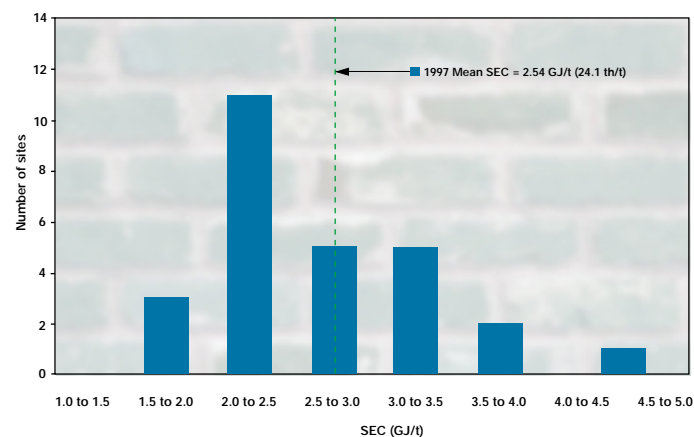


Fig 8b Specific Energy Consumption including electricity: tunnel kiln sites producing extruded shale bricks

INTERMITTENT KILN SITES

INTERMITTENT KILN SITES

The survey data indicates that a total of 144 intermittent kilns were being operated on 47 sites. Approximately 92% of the intermittent kiln tonnage, comprising a diverse range of products, was produced on 24 dedicated intermittent kiln sites. On the 23 multi-kiln sites, the intermittent kilns were used to fire the specials produced to complement the standard bricks.

The SEC for the different intermittent kiln plants is illustrated in Figures 9 and 10. A single

dedicated site and five multi-kiln sites with specific energy consumptions greater than 10 GJ/t are noted in the final columns of the two Figures. The weighted average SEC for all the ware fired in the intermittent kilns was 4.96 GJ/tonne. When the dedicated and multi-kiln sites are treated separately the energy consumptions are 4.74GJ/t for solely intermittent sites and 7.59 GJ/t for sites with mixed kilns. This difference reflects the better integration of the making, drying and firing processes on the sites with only intermittent kilns.



SURVEY CONCLUSIONS

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There is a large variation in energy consumption within non-fletton brickmaking. The following factors influence energy consumption for continuous and intermittent kiln plants:

- The type of kiln. Firing efficiency will be influenced by the type and age of the kiln. In the case of outwardly similar production units variations in energy usage can be more directly attributed to specific energy saving measures in use.
- The product range. For continuous kiln plants the making method will influence the energy used in drying. Variations in energy consumption will result from the different inherent firing characteristics of the UK brickmaking clays.
- Level of production. For tunnel kiln plants in particular, energy efficiency is dependent on maintaining the designated optimum throughput.
- Body fuel. Significant amounts of energy are potentially available from body fuel.
- Heat transfer. Where cooling kiln heat is used for drying this will markedly reduce the SEC.

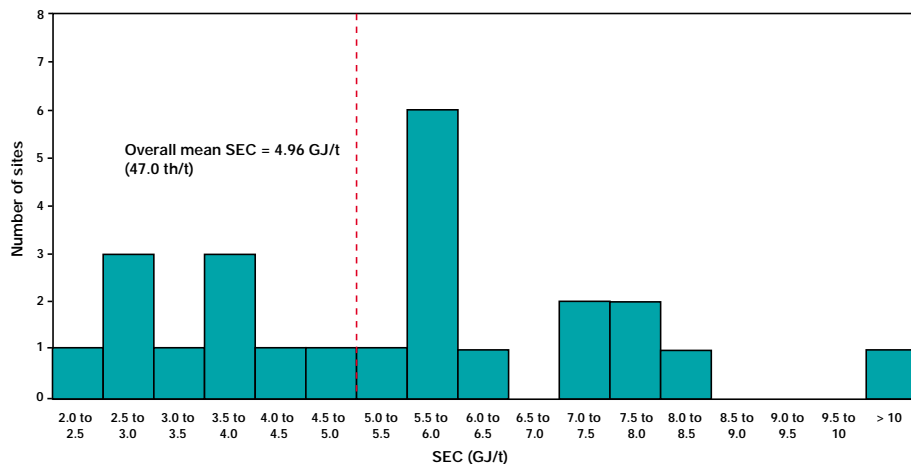


Fig 9 Specific Energy Consumption for intermittent kiln production. Dedicated sites, SEC = 4.74 GJ/t (44.9 th/t)

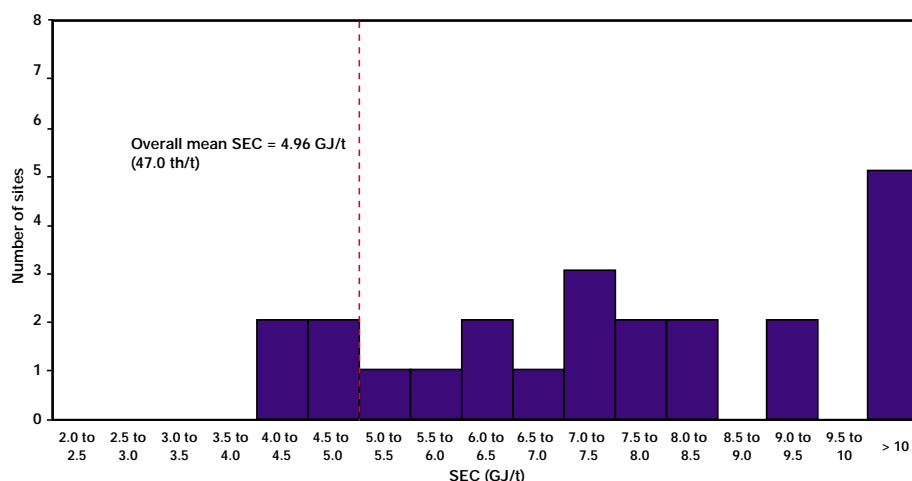


Fig 10 Specific energy consumption for intermittent kiln production. Multi-kiln sites, SEC = 7.59 GJ/t (71.9 th/t)

MEASURING PERFORMANCE

MEASURING PERFORMANCE

To compare your company's energy usage with others in the same sector you can use the energy consumption calculator in Table 2. This enables the net SEC to be calculated as energy usage per fired tonne. For all continuous kiln sites the calculated SEC can be compared with the industry analysis in Figures 6a and 6b. Where extruded bricks are produced from shales and fired in tunnel kilns, Figures 8a and 8b will give a more accurate comparison.

The performance of intermittent kiln sites may be compared with the overall industry performance information given in Figures 9 and 10. When comparing your SEC with the plotted SEC, you should note that the mean equivalent electrical energy contributions for products fired in continuous and intermittent kiln plant in 1997 were 0.20 and 0.24 GJ/tonne respectively.

Table 2 SEC Calculator

Energy used/year			
Solid:	Coal	Tonnes x 27.3 =	GJ
	Coke	Tonnes x 29.8 =	GJ
Liquid:	Medium Fuel Oil	Litres x 0.041 =	GJ
	Gas Oil	Litres x 0.039 =	GJ
Gas:	LPG (propane and butane)	Tonnes x 49.4 =	GJ
	Landfill*		GJ
	Natural	Therms x 0.106 =	GJ
Electricity		kWh x 0.0036 =	GJ
Total annual site energy use:			(1) GJ
Annual fired output			(2) Tonnes
Site specific energy consumption (SEC)			(1) ÷ (2) GJ/tonne

* Normally calculated in terms of natural gas equivalence.

MEASURING PERFORMANCE

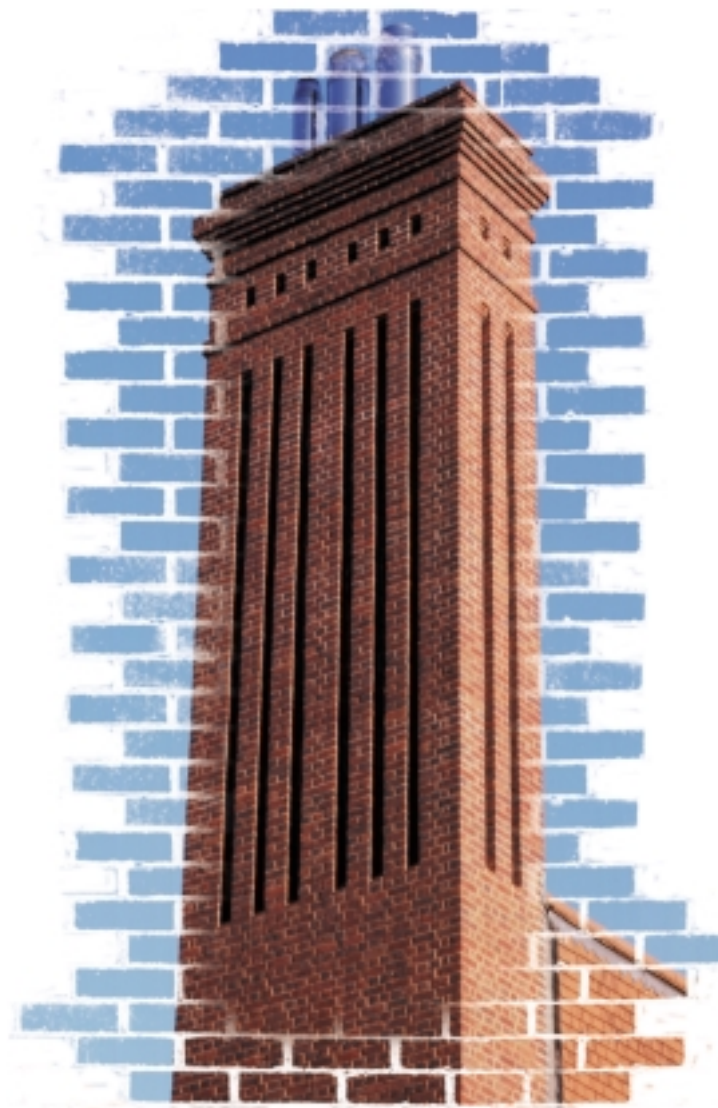
As an aid to compiling the calculator the following conversion factors can be used:

$$1 \text{ GJ} = 9.48 \text{ th} = 277.8 \text{ kWh}$$

$$100 \text{ ft}^3 \text{ natural gas} = 1.042 \text{ th} = 0.105 \text{ GJ} = 30.56 \text{ kWh}$$

In using the calculator it is important to realise that:

- No account has been taken of the potential energy contribution of body fuel.
- The calculator takes no account of the energy used in clay winning, internal transport and road transport. For those sites where information was provided the energy used amounted to 43 MJ/t.
- The calculator can be adapted for use over time periods shorter than one year. Monitoring the SEC over regular shorter intervals would enable any changes to be identified and, where necessary, remedial action to be taken.
- The calorific values for coal, coke and oil vary - the values used are taken from *Digest of UK Energy Statistics, 1999* (Government Statistical Service).



IMPROVED ENERGY EFFICIENCY

IMPROVED ENERGY EFFICIENCY

What can you do to improve your performance? Shown below is an action plan to achieve immediate low-cost energy saving. This is followed by specific energy-saving measures which are being adopted within the industry.

ACTION PLAN

- Raising awareness - to achieve savings by involving the workforce, either as individuals or in teams, in an ongoing good housekeeping project. This is likely to prove particularly effective in making electricity savings since considerable energy is wasted in supplying power to idling machinery and lighting.
- Metering and monitoring - to extend the good housekeeping scheme to meter the energy consumption and to monitor production on a regular basis. The results should be used to compare the performance of the plant with other plants within your company and the industry sector.
- Determining performance - to assess the ongoing individual plant performance by regularly completing an SEC Calculator.
- Target setting - initially to meet the mean sector performance. If this proves immediately or readily attainable more challenging targets should be set.
- Maintaining momentum - to maintain the impetus of the energy efficiency action plan by carrying out regular reviews to evaluate the measures put into operation. It is important that the information is disseminated to staff to maintain their interest and motivation in promoting further energy-saving initiatives.



ENERGY SAVING MEASURES

ENERGY SAVING MEASURES

Listed below are a series of potential energy saving measures which are being investigated within the clay brickmaking industry. In some instances helpful information has been supplied by industry personnel which has enabled particular measures to be quantified.

Production optimisation - for tunnel kilns in particular, maximum production efficiency is achieved by using the kiln to produce its designated throughput. Since the firing process is the most energy intensive of the production processes it is essential that the making and drying processes are carefully integrated to achieve the most efficient optimisation.

Waste heat recovery - the principle of utilising cooling kiln heat is well established particularly on continuous kiln plants. Its effectiveness will be influenced by the heat transfer system and more particularly by its recirculation in the dryer. Work on older dryers has identified drying energy savings of up to 20%. The use of the largely metallic heat exchangers for recovering heat from kiln exhaust gases has been investigated and subsequently discounted by the clay brickmaking industry. However, it is possible that this method of energy saving may be revisited in the light of current developments in the production of polymer-based exchangers.

Variable Speed Drives - significant electricity savings can be made by replacing fan damper control with Variable Speed Drives (inverters). Examples of power savings that can be effected by using inverters to replace damper controls on fans fitted with inlet and discharge dampers are shown

in Figures 11 and 12 respectively. In one case the use of inverters was shown to produce a 10% saving in electricity usage, ie a reduction from 165 to 148 kWh/1,000 bricks for the site.

Kiln car maintenance - the regular refurbishment of kiln car stock is essential in maintaining the seals between the cars and the kiln structure and between the cars themselves. The elimination of under-car heat losses has been shown to improve the temperature distribution in the brick setting and to produce improved yields. Ultimately when kiln cars need to be replaced further long-term benefits will be obtained by taking advantage of the improvements in kiln car design.

Fibre linings - because of its low thermal mass, ceramic fibre is particularly useful in producing energy savings during the continual firing of intermittent kilns. With increasing health and safety requirements, however, care must be exercised in the choice and installation of the linings. Problems relating to the use of refractory ceramic fibre have been addressed by HSE² and in a joint study carried out by ECFIA/BCC³. Further guidance is given in the Energy Efficiency Best Practice Programme's Good Practice Guide 244.

Replacement burner systems - energy savings during firing can be achieved by optimising the burner system. This can be carried out either by realignment of the existing burners or by their replacement with a more energy efficient system. A comparison between two identical tunnel kilns showed that a saving of 0.75 GJ/t had resulted from a change from side to top firing.

² Information Document HSE267/3. *Hazards from the use of refractory ceramic fibre.*

³ ECFIA/BCC Joint Study. *Working with ceramic fibre in the ceramics industry. A practical guide.*

ENERGY SAVING MEASURES

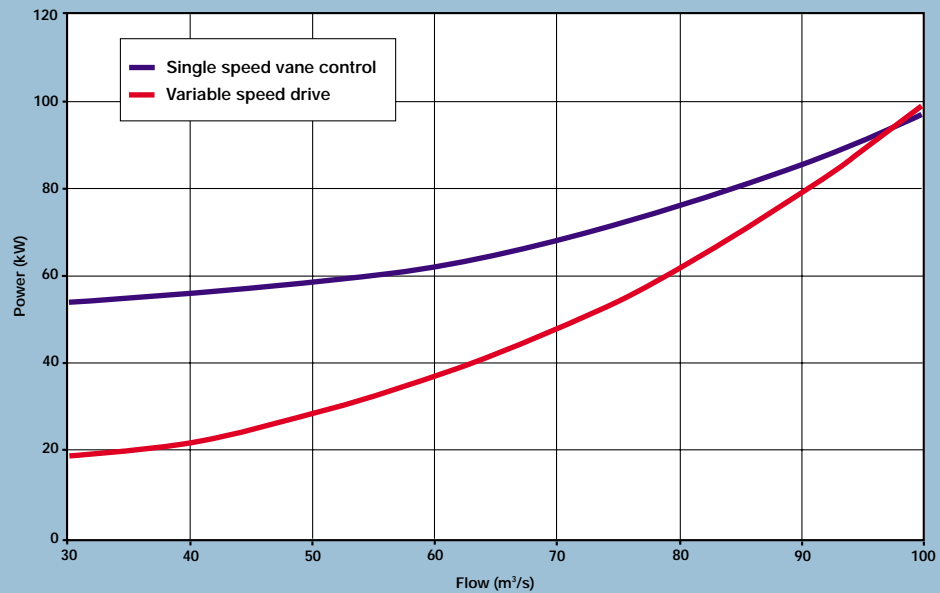


Fig 11 Influence of inverters on power usage - fans fitted with inlet dampers

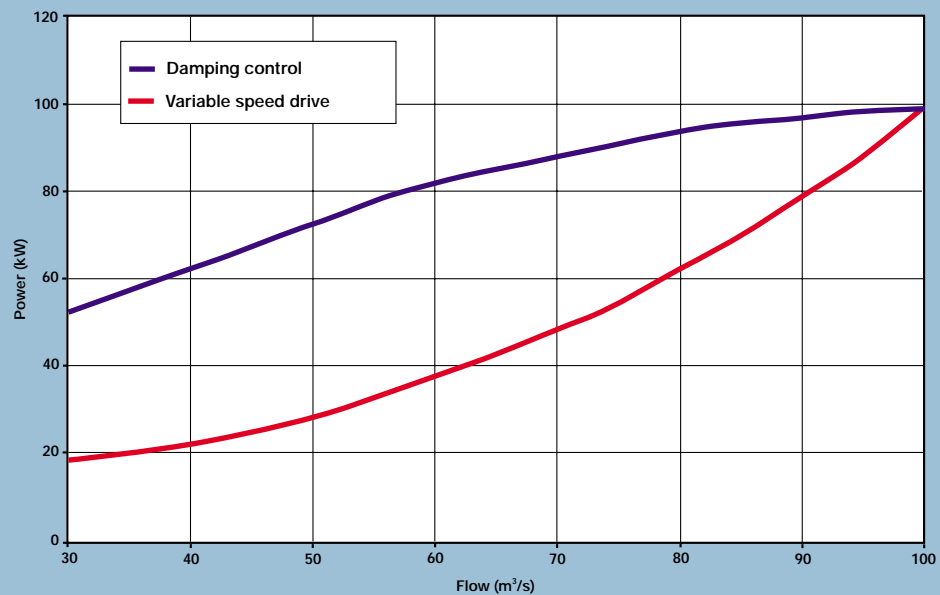


Fig 12 Influence of inverters on power usage - fans fitted with discharge dampers

ENERGY SAVING MEASURES

An area where replacement, rather than resiting, of burner systems has proved effective is in the change to pulse firing. Figures provided by a manufacturer using a tunnel kiln to fire soft mud bricks show that the use of pulse firing resulted in energy savings in two interrelated areas. Initially the change to pulse firing reduced the firing energy usage from 5.9 GJ (56 th) to 5.3 GJ (50 th) per 1,000 bricks. Subsequently the better in-kiln temperature distribution facilitated a faster push rate, which reduced the energy usage further to 4.7 GJ (45 th) per 1,000 bricks.

Another example of potential savings resulting from improved burner technology, applicable to intermittent kiln firing, is the use of recuperative burners. This technique involves passing hot exhaust gases through heat exchangers providing heat to warm the combustion air and improve the burner efficiency. The success of the technique lies

in utilising the exhaust gases without affecting the temperature distribution within the kiln.

Combined heat and power - a more significant step forward in the implementation of energy saving measures is capital investment in combined heat and power (CHP) systems, which simultaneously generate both electricity and heat. CHP installations are classified in three broad categories, which can be adopted to produce different heat/power ratios. The three alternative systems use gas turbines, steam cycle CHP systems and reciprocating engines.

Within the brickmaking industry evaluation of the potential of CHP has been limited to the use of gas turbines. Further information on CHP is available from the Energy Efficiency Best Practice Programme - contact the Environment and Energy Helpline (0800 585794) for further details.



FURTHER INFORMATION

FURTHER INFORMATION

Many of the energy-saving techniques covered in this guide are described in detail in the following Good Practice Guides:

- **GPG 164 *Energy efficient operation of kilns in the ceramics industry*** - this describes the techniques that lead to cost and energy saving, and gives guidance on how to select the appropriate techniques for you.
- **GPG 244 *The use of low thermal mass materials and systems in the ceramics industry*** - which describes the benefits of using LTM materials and highlights the factors you must take into account when using them.
- **GPG 248 *Energy efficient operation of dryers in the ceramics industry***. This gives advice on dryer operation, control, monitoring, process optimisation and problem-solving, to save money and energy.

These and other publications are available free of charge from the Energy Efficiency Best Practice Programme. Further details can be obtained by calling the Environment and Energy Helpline on 0800 585794.

If you would like to take part in future energy surveys of the brick industry, please contact CERAM Research who will be carrying out further surveys. Tel: 01782 764476.

With thanks to the Brick Development Association for supplying a number of the photographs in this Guide.



The Government's Energy Efficiency Best Practice Programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry, transport and buildings. The information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice Programme are shown opposite.

Further information

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Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R & D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Energy Efficiency in Buildings: helps new energy managers understand the use and costs of heating, lighting etc.